

# UMTS-AUCTIONS IN EUROPE

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During 2000 several European countries have auctioned UMTS licences. Holders of these 3G licenses can offer fast mobile Internet access and mobile video telephony services. The auctions have had drastic consequences for shares of telecoms operators and in all countries, apart from the UK, they have been accompanied with allegations of possible collusion among firms. In some countries, such as the Netherlands, where the auction was considered a fiasco, they have led to political problems as

well. In this short paper we discuss some (game theoretic) issues related to the design and playing of these auctions.

## 1. INTRODUCTION

Auctions are an ancient and common market institution. Herodotus describes that auctions were already used in Babylon some 4000 years ago (Van Damme, 1997b, Shubik, 1980 ). We all know the ascending auctions used to sell art and the descending auctions to sell fish and flowers in the Netherlands. In a seminal article, the later Nobel Prize Winner William Vickrey introduced and analysed the first formal mathematical (game theoretic) model of auctions (Vickrey, 1961). For the case in which a single object is auctioned, Vickrey addressed the buyer's problem of how to bid as well as the seller's problem of what auction form would raise the highest expected revenue. Given some additional (symmetry and independence) assumptions, Vickrey proved a version of the remarkable Revenue Equivalence Theorem, which states that all commonly observed auctions yield all participants the same expected utility. A good description of the significance of Vickrey's work may be found at the site of the Nobel foundation: [www.nobel.se/economics/laureates/1996/](http://www.nobel.se/economics/laureates/1996/).

At about the same time as Vickrey wrote this seminal auction paper, another later Nobel Prize Winner, Ronald Coase, criticized the active involvement of the government in spectrum policy and spectrum management (Coase, 1959). Acknowledging externalities resulting from problems of interference, Coase argued that the role of the government would best be limited to clearly defining property rights and that the allocation of these rights should be left to the market. In particular, transferring the initial rights from the government into private hands could be done through an auction mechanism. (See [www.nobel.se/economics/laureates/1991/](http://www.nobel.se/economics/laureates/1991/)). It took some 40 years before Coase's ideas were implemented in practise. The first spectrum auctions, which took place in Australia and New Zealand were, however, not a complete success. The failure of the traditional auction mechanisms to deliver the desired results put the issue of auction design on the agenda. The FCC, the US agency responsible for spectrum management, consulted extensively with academic experts about how to optimally allocate multiple licences before actually engaging in spectrum auctions. The academics proposed a simultaneous multiround auction, and after this format had been tested in the experimental lab, it was brought to the field. After experience had shown the design to work well in the US, the same format was used in Europe to allocate spectrum licences, with the Dutch DCS-1800 auction to be one

of the first on the old continent. (See Van Damme (1997a) for a description of the history, and Van Damme (1999) for a critical evaluation of this Dutch DCS-1800 auction.)

In most European countries, licences for second generation (i.e. digital) mobile telephony networks have been given out for free, after a so called beauty contest, in which business plans of different operators are compared. Governments, however, realised that in this way they were giving away “licences to print money”. When it became clear that, for third generation networks (that enable fast mobile Internet access and video telephony) vast sums of money were at stake, most of them decided to switch to the auction mechanism. Up till now, the UK, the Netherlands, Germany, Italy and Austria have held auctions and Switzerland and Belgium are about to do so soon. In the next section, we briefly describe the problem that these governments had to solve. Thereafter we describe the solution (the auction form) that was chosen in these countries and the specific problems that this caused for the players (firms) participating in these auctions. We also describe how the players prepared themselves and some elements of the strategies that were used.

## **2. THE GOVERNMENT’S PROBLEM**

A formalization of the government’s problem should specify the goal of the government and the constraints that it faces. From the official documents, usually available on the relevant web-sites of the government agencies that organise the auctions, one sees that two goals play a role: (i) creating a competitive telecommunications market and (ii) raising revenue. In some countries, such as the Netherlands, only the first goal is explicitly mentioned. Note that the two goals generally will be in conflict: in a competitive market the firms’ profit will be low, hence, firms will not be willing to pay much for a licence so that the government’s revenue will be low as well. This raises the question about what should count more heavily, efficiency or revenue? We formulate this question more generally as “why auction?”.

### **2.1 Why auction?**

The answer from standard theory, as already given by Vickrey, is that an auction generates an efficient outcome. Given Vickrey’s assumptions, an auction guarantees that the object ends up with that

firm that values it most. Furthermore, in Vickrey's setting, the expected revenue is equal to the second highest value, so that, essentially, there is no conflict between the two goals mentioned above. The problem, however, is that Vickrey's assumptions do not hold in the present setting. For one, an auction may generate an outcome that is efficient from the firms' point of view, but this need not be efficient for consumers. Secondly, firms typically are in asymmetric positions, some are incumbents while others are entrants and an ordinary auction may give entrants a smaller chance of winning (see below).

Comparing auctions to beauty contests, firms, and in particular incumbents, typically prefer the latter. The argument is clear: they are likely to win in a beauty contest and they don't have to pay. Having to pay an auction price lowers the value of the firm, hence, it lowers the share price. Shareholders, hence, don't like auctions. Taxpayers, on the other hand, do like them as the revenues that the auction brings in can be used to reduce other taxes. The welfare gains can be considerable as standard taxes are quite distortive. In the political debate about auctions, emphasis has been on the question of whether auction prices result in higher prices for telecoms users, the layman's argument being that firms have higher cost and that they will pass these on to consumers. Economists are sceptical about this argument, they argue that the auction price constitutes a sunk cost, hence, that it will be irrelevant for the market price as this is determined by the market conditions. (See McMillan, 1995)

## **2.2 Auction what?**

Through international agreements, 60 MHz of spectrum has been reserved for third generation telecoms systems. Technical (network) requirements imply that this has to be split up in blocks of 5 MHz each and that at least a capacity of 10 MHz is needed to be able to operate a network. It follows that only 3 possibilities exist: (i) 4 licences of 15 MHz each, (ii) 2 licences of 15 MHz each and 3 licences of 10 MHz each, (iii) 6 licences of 10 MHz each. In addition, there is the design choice of whether the number of licences should be fixed in advance, or whether the market itself should determine which of the possibilities (i)-(iii) will result. The latter option was chosen in Germany and Austria where 12 blocks of 5 MHz were auctioned and where each player that succeeded in acquiring at least 2 blocks received a license. All other countries specified the market structure exogenously (see below).

Another important design choice is whether to assist new entrants or not. New entrants are disadvantaged as they do not yet have a physical network, nor customers. Therefore, they will have higher cost in building up the new network and they will associate a lower value to a licence. In the situation where there are as many licences as incumbents, entrants, therefore, have little chance of winning in the auction. In the Netherlands, Versatel complained about unfair treatment and the “closed shop” arrangement of having 5 licences and 5 incumbents, a complaint that is presently handled by the courts. In the UK, also 5 licences were auctioned, but there were only 4 incumbents, hence, one licence could be reserved for a new entrant. In the UK, entrants were also helped by the fact that they were giving rights to use incumbents’ networks until they had rolled out their own network, hence, they can start offering ordinary 2G-services right away.

### **2.3 How to auction?**

The third problem that governments had to solve was what auction rules to use. Here all countries used a variant of the simultaneous, ascending multi-round auction that had been tested in the US, although there were important differences between the countries. (See below.) In such an auction, all licences are sold simultaneously. The auction starts at a low price and lasts until no more bids are made. In each round, bidders are informed about the current state, such as which bidder is standing high on which lot for what amount, and each bidder that is not currently standing high on one of the lots can choose one of the lots and enter a bid there. A bidder is free to choose the lot (if a bidder has bid on *A* before, but is not standing high there, he may later bid on *E*, for example) and the only restriction on the bid is that it tops the current high bid with a certain known percentage (such as 10% at the start of the auction, 5% later, and 2% near the end). The auction ends when no more bids are made. Those players that are then standing high get the licences and each winner pays his bid.

### **3. THE BIDDERS’ PROBLEMS**

Once the government has made its decision and has determined the auction rules, the (potential) bidders face a well defined bidding game. Each player will determine the value that it assigns to winning a licence and the budget that it has available. Each bidder will specify a goal (such as to win a licence at minimal expenditure) and will think about a strategy for obtaining that goal

The Discounted cash flow model is the main tool for determining value. Assume, for concreteness, that one expects to get revenue of Dfl. 100,-- per month for each subscriber and that one discounts with 1% per month. The latter is the WACC, the weighted average cost of capital, the amount that one has to make to convince investors that it is worthwhile to invest in the project. If it takes two years to roll out the network, and, hence, revenues start to flow in only then, total discounted revenue is about Dfl. 7500 per subscriber. If one counts on 6 million subscribers and a market share of  $\alpha$ , then one gets expected revenue of Dfl. 15 bln. From this one has to subtract the cost of actually building and maintaining the network, say Dfl. 3 bln., to get to the value of Dfl. 12 bln. What is clear from this calculation is that main determinants of value are WACC (the higher these costs, the lower the value), ARPU (average revenue per user), market share and cost of building a network. It should also be clear that value will typically be lower for newcomers to the market: they can expect only a lower market share, it will take them more time before revenues start to flow in and they have higher cost in building a network. (Fortis Bank estimates that, in Belgium, the construction cost are 30% higher for a newcomer, see *Financieel Economische Tijd*, October 13, 2000.)

The game that is played is one of incomplete information as a bidder will not be completely informed about the goals and budgets of its competitors. Technically, the UMTS-auctions have a large common value component: if I assign a high value to a licence, then this is because I expect the 3G-technology to be popular (high ARPU), but then, most likely, the value that a competitor assigns to a value will be high as well. Because of this common value element, there is the risk of the “winner’s curse” and to avoid it I have to incorporate the fact that winning a licence may actually be bad news.

The game is a difficult one to play and optimal (equilibrium) strategies are not known explicitly. To gain confidence in a certain strategy and to find out which strategy might be best, a player typically organizes mock auctions before the actual auction takes place, i.e. one simulates the actual auction in an experiment.

We now describe the various auctions that have already taken place in more detail. The following table gives an overview of the revenues (in Euro per inhabitant) that have been generated in the various countries that have allocated licenses thus far. One sees that there are considerable differences. We note that Finland and Spain have used a beauty contest and that France is going to sell the licenses for

a fixed price. All other countries mentioned have used the auction mechanism.

Country	Revenu (€/pop)
Finland	0
Spain	15
United Kingdom	648
Netherlands	171
Germany	613
Italy	240
Austria	82
France	337

### 3.1 The UK-auction

This was the first UMTS-auction that took place in Europe. Economists from Oxford and University College London, teams led by Paul Klemperer and Ken Binmore, had a great influence on the design of the auction, see [www.spectrumauctions.gov.uk/3gindex.htm](http://www.spectrumauctions.gov.uk/3gindex.htm) and Klemperer (2000). 5 licences were sold, *A* and *B* were 15 MHz each, while *C*, *D* and *E* each offered 10 MHz of spectrum. Licence *A* was reserved for new entrants, only newcomers to the market were allowed to bid on this licence. This “carrot” attracted many potential entrants; besides the 4 incumbent mobile operators 9 newcomers participated in the auction. Of course, newcomers did not bid only on *A*, they drove up the prices on the other lots as well. During the auction, as prices went up, more and more players dropped out of the auction. Finally, the auction stopped after 150 rounds, with TIW (in which Hutchison participated) winning *A* for  $\text{£}4.4$  bln, Vodafone winning *B* for  $\text{£}6$  bln. and *C*, *D*, *E* going to the other 3 incumbents (BT, One2One, Orange) for a price of  $\text{£}4$  bln. each. The interested reader may consult [www.spectrumauctions.gov.uk/auction](http://www.spectrumauctions.gov.uk/auction) where full information on the bidding behavior is provided.

The UK-auction ran very smoothly, albeit slowly. Newcomers typically bid cautiously, mostly on the lot that was cheapest. The main problem for incumbents was to decide whether it was worthwhile

to bid on the larger lot, and how much extra one was willing to pay for this larger one. Here bidders displayed different behavior, some bidders bidding only on the small lots, others (Vodafone) only bidding on  $B$  and yet others (BT) switching opportunistically between  $B$  and the smaller lots. In the end, the auction raised considerable revenue for the government (Euro. 650 per UK-inhabitant), much more than analysts had expected.

### 3.2 The auction in the Netherlands

As in the UK, 2 large licences ( $A$  and  $B$ ) and 3 smaller ones ( $C$ ,  $D$ ,  $E$ ) were auctioned. None of these was reserved for a newcomer. This, together with the fact that already 5 players were present in the market, implied that newcomers showed little interest to participate. DT, for example, decided not to compete in the auction, but to join forces with one of the existing players, Ben. Similarly, Hutchison and NTL, being linked with incumbent operators KPN and Dutchtone, respectively, decided not to participate. In the end, only one newcomer, Versatel, showed up in the auction.

One may wonder why Versatel participated in the auction, given that it knew that it could not win the auction. My theory, which I have explained elsewhere (Van Damme, 2000) is that Versatel participated only in the auction to get favours from existing operators. By staying in the auction, Versatel could drive up the price for the others, clearly something that the incumbents do not like, hence, they should be willing to pay Versatel to avoid it happening. Versatel had indicated that it was willing to step out, if given sufficient compensation. After the auction had been going on for two weeks, the lawyer of Telfort wrote a letter to Versatel indicating that it had understood Versatel's motives. Versatel interpreted the letter as a "threat" and quit the auction, hence, the auction ended suddenly and unexpectedly. At present, investigations are still going on about whether Versatel and Telfort colluded. (On November 1, a government hearing revealed that there had been talks between the firms already on the first day of the auction and on November 3, the Dutch competition authority, the NMa, decided to "raid" the two firms' offices to search for evidence of collusion).

A couple of other aspects of the Dutch auction were interesting as well. The auction started with all players, other than Libertel, not bidding but issuing waivers. This had the consequence that the minimum price for the lots was reduced to zero, hence, if the auction would have stopped there, the



licences would have been given away for free. Some observers thought that this behavior might be evidence of collusion. In my opinion, issuing a waiver at a start was a dominant strategy since waivers only had positive value at that time. The main problem a bidder faced during the auction was deciding on the premium it was willing to pay for a large lot. It was generally expected that the 2 large lots would go to the 2 players with the largest market shares. During the auction, KPN only bid on large lots, while Libertel sometimes switched to smaller ones. Furthermore, there were actually small differences between the large lots (and between the small ones as well) and players had to act skilfully to obtain that lot that was desired most. In the end, the large lots went to KPN and Libertel for a price of approximately Dfl. 1,5 bln., and the small lots went to the other incumbents for a price of approximately Dfl. 1 bln. each. (See [www.veilenvanfrequenties.nl](http://www.veilenvanfrequenties.nl) for more details.) The total revenue was only about 1/4 of what the Minister of Finance had expected and revenue per inhabitant was only Euro 171.

The low revenue generated, together with the sudden ending of the auction (and the possible collusion and insider trading, the latter resulting from the fact that on the last day Telfort was the only incumbent that knew that Versatel would not bid any more) has led to a lot of public discussion about the design of the auction and the adequacy of the competition oversight during the auction. Parliament decided to organize a special investigation about the auction, which presently is under way and which will presumably lead to the conclusion that more scientific input in the design would most likely have led to a better outcome.

### **3.3 The German auction**

The Germans used a different design. They auctioned 12 abstract blocks of 5 MHz each. Bidders could acquire 2 or 3 of these blocks, hence, market outcomes with 4, 5 or 6 bidders were possible. Given the fact that the blocks were perfectly interchangeable at the time of the auction, it is somewhat hard to understand why the Germans allowed bids on the different lots separately and why each lot could carry a different price. To see how strange this is, imagine that on the AEX you could bid on each share AHOLD separately and that different shares could have different prices. Given their setting, the Germans could have simply asked bidders to express their demand at the current price (either 0, 2 or 3 blocks) and then to increase this (single) price until total demand would be equal to total supply (=

12). Hence, we would simply have the standard supply-demand diagram from Introductory Economics and would increase price until equilibrium would be found.

Especially interesting is the fact that this German design can allow multiple equilibria. The German 2G-market is characterized by 2 large incumbents (DT and Vodafone/Mannesmann) and 2 small ones (E-plus (partially owned by KPN) and Veba (owned by BT)). It is natural to assume that, for each of these players, the value in a 4-player market is larger than when a 5<sup>th</sup> or 6<sup>th</sup> player enters. For concreteness assume  $L_4 = 10$ ,  $L_5 = L_6 = 6$ ,  $S_4 = 9$ ,  $S_5 = S_6 = 5$ , where the subscript denotes the number of players in the market and letters designate the player's type,  $L$  for a large incumbent,  $S$  for a small incumbent. Assume, in addition that there are two equally strong entrants with  $E_5 = 4$  and  $E_6 = 2$ , and that, in addition, there is one weaker entrant. The rules of the German auction specify that players cannot increase their bidding rights, i.e. if a player expresses demand for only 2 blocks at price  $p$ , then his demand can be at most 2 at any higher price. Assume that when the weaker entrant drops out (which happens at  $p < 1$ ), all remaining players have 2 bidding rights left. In that case the auction stops at that price and there will be 6 winners. Assume that all incumbents still have 3 bidding rights at that price. If price increases above 1, one of the stronger entrants has to drop out, and the price will increase to 2. There is another equilibrium in which each incumbent drops his third bidding right between 1 and 2 and which results in 5 winners at price  $p = 2$ . Finally, there is yet another equilibrium in which all incumbents keep all bidding rights as long as possible and only the 4 incumbents win, at the price  $p = 2$ . Some economists had predicted that price would indeed go up until only incumbents would remain in the race (For details on this argument, see Jehiel and Moldovanu, 2000).

This is not what happened in the auction and the actual outcome was somewhat of a surprise. During the auction, DT and Mannesmann drove up price thereby attempting to drive out one or both of the new entrants, Telefonica or FT/Mobilcom. This, however, was not successful and the auction ended with 6 winners. Immediately after the auction, Hutchison stepped out of the consortium it had formed with KPN with the argument that it considered prices to be too high. This halved the market value of KPN and led to a general impression that it would be next to impossible for Telefonica to recoup the auction prices. Hence, Telefonica, and possibly also FT and E-plus and Veba, might have fallen prey to the winner's curse in this auction.

At [www.regtp.de](http://www.regtp.de) (under “Rundenergebnisse”) the interested reader can see the details of the bidding behavior. Interesting is the fact that some players, such as Mobilcom, were successful in defending their territory, they increased prices on their own lots to scare other players and to force them to bid on other lots. Interesting is also the fact that Mobilcom offered one of the other players, Debitel, room on its network would it win one, thereby giving this player an attractive outside option and thus lessening the competition. Hence, this might also be viewed as an offer to collude. In the end, the German auction raised more than DM 100 bln., hence, approximately Euro 613 per inhabitant.

### **3.4 The Italian auction**

The Italian auction was the simplest of those that have taken place thus far. In Italy 5 abstract blocks of 10 MHz were auctioned. This left 10 MHz, which was sold, at a discount, to new entrants to the market. Hence, this served as a carrot to attract entrants. In the Italian auction bidders were ranked according to their bids and those bidders that were not among the five highest had to top the current 5<sup>th</sup> highest bid by at least 2% or quit the auction. The auction continued until there were no more bids and then those bidders with the 5 highest bids were awarded the licences for the prices that they had bid. The auction started at a high minimum price of 4000 billion Lira per licence.

Initially 8 parties expressed interest. One of them, Anthill, did not meet the qualifications imposed by the government and was eliminated. A second bidder, TU-Mobile could not arrange sufficient finances and was eliminated as well. This left 6 bidders for the 5 licences, two newcomers IPSE ( a consortium of Telefonica and Sonera), and ANDALA (a consortium of Hutchison with Tiscali), in addition to Tim, Omnitel/Vodafone, Wind and Blu. The latter player was a consortium of BT (20%) with Italian shareholders. The shareholders got into a fight, and Blu withdrew from the auction. Hence, the auction ended already after 2 days. The government, being disappointed with the low revenue (half of what was expected) accused the bidders of colluding and at present a cartel investigation is under way. (Note that the situation is similar to that in the Netherlands since there was only one more bidder than licences, hence, the eventual winners would benefit if they could ex ante identify the loser and force him to quit early.) Fortunately for the Italian government, it had been so wise to set a high minimum price. Now the revenue raised was still higher than in the Netherlands (Euro 240 per pop), otherwise it would have been close to zero.

### 3.5 The Austrian auction

The Austrians used the same design as the one that had been probed in Germany. Only 6 players showed an interest in a license, however. The German auction had shown that a 6-player market was a possible outcome and it had also clearly demonstrated the risks and high cost involved in trying to eliminate one of the players from the market. Consequently, one might expect the players to indeed coordinate on a 6-player outcome. Just to make sure that coordination was indeed achieved, Heinz Sundt, the chair person of Telekom Austria (the former Austrian monopolist and largest player on the market) told reporters in the week before the auction that he would be satisfied with just two of the blocks, and that, if the others behaved similarly, it should be possible to get the frequencies on sensible terms. (See Total Telecom “Austrian UMTS auction unlikely to scale peaks, October 31, 2000.) According to Total Telecom, Sundt also stressed there would be no collusion among the bidders and that Telekom Austria's Mobilkom unit would bid for a third frequency block if one of its rivals did. In my opinion, Sundt has clearly demonstrated his good understanding of the logic of the “folk theorem”. Although the Austrian telecommunications authority warned that it would break off the auction if it detected collusion, it did not really act. Other players also understood Sundt’s message and the Austrian auction ended after just 14 rounds and one and a half day, leaving the government with a revenue of just 82 Euro per Austrian citizen.

## 4. CONCLUSION

The high stakes UMTS-auction that have taken place in Europe have put the issue of auction design firmly on the agenda of policy makers in Europe. The simple fact that licences constitute substantial value for market participants does not imply that governments can easily appropriate a large part of this value. Basically, only the UK-auction has performed fully satisfactory. Market participants quickly learned from that auction that competition drives up prices and that, hence, it may be better to cooperate than to compete. After the UK-auction, consolidation took place in the sector and the number of active bidders in the auctions was less than expected in all countries that followed the UK. Furthermore, in all of these countries there have been rumours of possible collusion among the

participants in the auctions. The general lesson learned is that a good auction design is essential to ensure that the government's objectives be reached.

This lesson is important not only for UMTS, but also for other auctions that are planned in the future. Here one may think of auctions for capacity in telecommunications, or in electricity networks, or auctions for licences to operate commercial radio stations, or gasoline stations. In all these cases the problem is more complicated than in the relatively simple UMTS-case, albeit that the stakes may be lower. This implies that it will be even more important to have a good design. Fortunately, economic theory contains a lot of useful insights for auction designers, see, for example, Klemperer (2000).

Having been involved in some of these auctions, sometimes on the side of the seller, at other times acting as an advisor to one of the bidding parties, I can state that auctions are not only challenging academically, it is also fun to play these games, even when they are for high stakes.

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